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ABSTRACT

Based on reviews of 10 examples of multimedia design, this paper presents an introductory framework for reflecting on the issues involved in the design of interactive multimedia instructional programs for discovery learning. High school students, junior and senior high school teachers, and Center for Technology in Education (CTE) staff reviewed the programs in the CTE multimedia lab, using and discussing them from the standpoint of consumers as well as design critics. This paper provides a synthesis of their different perspectives on the programs' characteristic features in the form of questions designed to help educators to better understand and evaluate these and other new multimedia materials. Discussions of the design issues are organized according to what appear to be the basic design components of most discovery-oriented multimedia programs and the major design considerations in each category: (1) a database of information, with a particular content (depth vs. breadth, media formats, realism, point of view, and connection to curricula) and a particular database structure (nature of the raw materials, browsing vs. direct searching and sorting, use of contextual metaphors and organizers, and structured activities); (2) a computer software user interface for accessing the information (contextualizing overview, locational information, visual/spatial access, multiple options, and system responsiveness and consistency); and (3) interactive tools for manipulating the information (personalizing; searching, sorting, and browsing tools; linking and tracing; editing and authoring; and producing, composing, and programming). (10 references) (DB)

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Looking at Multimedia: Design Issues in Several Discovery-Oriented Programs

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OVERVIEW

Multimedia programs for education are becoming more numerous and diverse, yet the universe of discourse about multimedia in education has not kept pace with the rapid evolution of design ideas. Despite the variety of new programs, the claims made for their utility and efficacy are often uniformly positive, and tend to sound alike. As a result, educators now face a proliferation of choices, often lacking the concepts and vocabulary that might form a critical lens, helping them to distinguish, for example, between a well-designed program that provides lasting opportunities for inquiry and engagement, and one that does not. Educators need a critical lexicon that will be useful to them in looking at and thinking about new programs. Such a lexicon seems especially important now, when multimedia systems are still quite costly and often difficult to manage.

As one contribution to the development of a critical vocabulary for multimedia design, this paper presents a framework for reflecting on the design of discovery-based multimedia programs, based on a review of several multimedia design examples collected during the second year of work by Bank Street College's Center for Technology in Education (CTE). Children, teachers, and CTE staff reviewed the programs in the CTE multimedia lab, using and discussing them from the standpoint of consumers as well as design critics. This paper provides a synthesis of their different perspectives on the programs' characteristic features, in the form of questions that we hope educators can use to better understand and evaluate these and other new multimedia materials. Our discussion of the design issues is organized according to what appear to be the basic components of most discovery-oriented multimedia programs: a database of information, a user interface for accessing the information, and interactive tools for manipulating it.[1]

WHAT DO WE MEAN BY "NEW MULTIMEDIA PROGRAMS"?

As we use it here, "multimedia" refers to an evolving set of teaching and learning tools that, in their most sophisticated form, combine motion video images, sounds, text, and graphics in a computer-driven environment under the user's control. A single program on animal biology, for example, might allow a teacher to illustrate cell division with a slow-motion sequence from a videodisc, a team of students to manage a computer-simulated island ecosystem, and an individual student to research and write an on-line report comparing the mating sounds of different mammals, with examples. Our review, however, was not an exhaustive look at the entire range of interactive multimedia programs currently becoming available for education. Instead, it was an attempt to sample a small number of programs that represent a particular pedagogical and design focus on "discovery learning," to look at them briefly with a critical eye, and to suggest a series of questions that can be applied more widely to other programs.[2]

What do we mean when we say that the programs have in common a "discovery orientation"? In large part, this means that all of them emphasize the user's central role as an agent in ordering and discovering connections between objects and ideas. Relative to many other technology-based approaches to learning, such as tutorials, drill-and-practice, programming, or games, discovery-oriented programs retain an open-endedness and flexibility that encourage users to play a more active role in the learning enterprise. However, since extreme open-endedness can risk the loss of continuity and coherence, discovery-based environments incorporate a variety of subtle means by which users can be guided and supported in navigating about and finding new connections. In addition, many discovery-oriented programs are two-way, not one-way, streets: Instead of simply receiving and manipulating information, learners can use tools that allow them to develop and synthesize their own ideas and insights along with or in response to the program material. An outline of these and other distinguishing design components forms the main body of this paper.

Despite their shared discovery orientation, however, the multimedia programs we looked at were by no means uniform. The content and scope of the programs differed widely, from an in-depth look at the 1988 presidential campaign to an almanac with hundreds of brief entries in science, history, and culture. We made an effort to include in our ten design examples programs that dealt with a range of subject areas (art, biology, physics, history, social studies) as well as programs that employed a variety of learning strategies (building from a narrative drama, simulating field experiments, inviting multiple means of browsing). The ten design examples we reviewed are:

1. *Exploring the Moon* (IRIS, Brown University, 1989).
2. *Interactive NOVA: Animal Pathfinders* (WGBH-TV, Boston, Peace River Films, Apple Computer Inc.'s Multimedia Lab, 1989 prototype).
3. *In the Holy Land* (ABC News Interactive, 1989).
4. *Life Story* (Apple Computer Inc.'s Multimedia Lab, Adrian Malone Productions, Lucasfilm Ltd., and the Smithsonian Institution,1989 prototype).
5. *Ludwig Van Beethoven Symphony No. 9* (London Records, a division of Polygram Records, Inc. and The Voyager Company, 1989).
6. *National Gallery of Art* (Videodisc Publishing, Inc., 1983; The Voyager Company, 1987).
7. *Ramos* (Insights, 1989).
8. *The '88 Vote* (ABC News Interactive, 1989).
9. *The Visual Almanac:* An Interactive Multimedia Kit (Apple Computer Inc.'s Multimedia Lab, 1989 pre-release version).
10. *Van Gogh Revisited* (Philips International, 1982, The Voyager Company, 1988).

Based on a selective review of these programs, this paper offers a series of questions that may be usefully asked of any new multimedia program. The form of the paper owes something to the nature of the multimedia materials themselves. We do not discuss individual programs in detail, but instead abstract from reviewers' discussions those issues and features that seemed most important and generalizable. This was a choice made necessary by the sheer size and diversity of options in each individual program: A thorough discussion of all the interesting and relevant design features in each program would occupy several books. Unfortunately, this means that many important and innovative aspects of each program go unremarked. We can only recommend that educators who wish to apply some of the questions outlined here to new multimedia programs begin with those referred to here. They can do no better.

HOW WERE THE REVIEWS CONDUCTED?

Our reviewers were a diverse group drawn from three different occupational categories, each with its own special interests and concerns: students who, as the ultimate consumers of new learning materials, are rightly concerned with their interest and appeal; teachers, alert to the educational integrity and usefulness of the materials; and Bank Street College researchers and designers, who worry about such things as the program's clarity, consistency and ease of use, and its developmental appropriateness. We hoped that a frankly subjective sketch of the new medium's potential strengths and weaknesses would be more reliable if we brought these different perspectives to bear in a review.

Six New York City public high school students, ages 14 to 16, were our student "expert reviewers." They worked in pairs in the lab, using six of the ten programs for 1.5 to 3 hours each, followed by a half-hour discussion of their reactions. Seventeen New York-area teachers from five junior high and high schools, both public and private, served as our teacher reviewers. Representing disciplines as diverse as social studies, art, science, math, and English, they each used and discussed one of the ten programs along with one or more colleagues for approximately one-and-a-half to two hours. The program chosen was sometimes, but not always, closely related to the teachers' area of expertise; choices were made according to interest, on the basis of brief written descriptions.

We asked the reviewers, children and adults, to consider the following questions while they used and discussed the programs: How useful and compelling do the materials appear? How easy are they to understand and use? What unique opportunities do they seem to present? What limitations or biases might they have? From reviewers' discussions of these questions (videotaped and informally analyzed by researchers), there emerged a clear sense that the programs varied significantly in terms of several key design features and considerations.[3]

In what follows, we discuss the major design features that emerged from our reviews. Because the reviews focused on a small number of very specific multimedia applications chosen for their open-ended, discovery orientation, this list of design considerations looks quite different from the questions that typically guide instructional design. For example, it does not rehearse important preliminary considerations, such as identifying the overall goal or purpose of the software, who is going to use it, or in what context. We omit these issues not because they are unimportant, but because we believe that new multimedia resources present designers and consumers with a wealth of design options and opportunities, even after initial decisions about audience needs and content, scope, and context of use have been made. It is important to remember, however, that this is not a list of features that are absolutely necessary for a piece of multimedia software to be considered effective. Rather, it is an introductory framework for reflecting more critically on the range of options and opportunities from which designers and educators might choose as they create and use a new generation of discovery-based multimedia software.

At the core, each of the multimedia examples reviewed appears to be comprised of three basic, and several complementary, design components:

1. **A database of information, with a particular content**
   a. Depth vs Breadth
   b. Media Formats
   c. Realism
   d. Point of View
   e. Connection to Curricula

   and **a particular database structure**
   a. Nature of the Raw Materials
   b. Browsing vs Direct Searching and Sorting
   c. Use of Contextual Metaphors and Organizers
   d. Structured Activities
2. **A user interface for accessing the information,** and
   a. Contextualizing Overview
   b. Locational Information
   c. Visual/Spatial Access
   d. Multiple Options
   e. System Responsiveness and Consistency
3. **Various interactive tools for manipulating the information.**
   a. Personalizing
   b. Searching, Sorting, and Browsing Tools
   c. Linking and Tracing
   d. Editing and Authoring
   e. Producing, Composing, and Programming

Important design considerations emerged under each of these categories. These are outlined below via a series of questions, followed by references to design examples which illustrate them.

In terms of **the content of the database,** one might ask the following questions:

a. **Depth vs Breadth.** What is the content of the database? Does it appear to be focused on one subject area or bounded by a central theme, or is it perhaps comprised of an encyclopedic array of subjects or a potpourri of themes? In other words, does it contain a narrow range of topics presented in a deep way, or a broad a range of topics presented in an introductory way, or some combination of both?

> The content of *Interactive NOVA: Animal Pathfinders,* for example, is focused on a central theme—animal migration. The content of

Life Story is focused on a central story—the discovery of DNA. Because the information in these design examples is bounded by a single theme or narrow range of themes, it tends to be presented deeply rather than broadly. On the other hand, the information in a design example such as *The Visual Almanac* (which consists, as its name suggests, of a sampling of diverse themes and categories of information) is presented broadly across the many themes, rather than deeply in any one category.

b. **Media Formats.** Does the database contain information presented in a variety of media formats—text, still images, moving images, sounds, graphics? Does any one of these formats, such as motion video or text, predominate? Are the different media integrated in interesting ways, or are they used more or less discretely?

Multimedia, by definition, means a variety of media formats. Some programs, however, integrate the media with a purpose. It may be using one medium to illuminate another, such as the *Ludwig Van Beethoven Ninth Symphony* accomplishes. Here, the listener's understanding and appreciation of the Ninth Symphony is enhanced by reading and manipulating textual, graphic, and musical annotations that appear on the computer screen as the symphony progresses. In *The Visual Almanac* , the purpose of media integration is often to provide representations of an abstract or complex idea. Teachers found very compelling, for example, an activity in which conservation of angular momentum could be explored through a combination of video footage (of a merry-go-round) and graphing on the computer.

c. **Realism.** Is the content of the database perceived to be "realistic," perhaps because it is based, at least in part, on photographically realistic films and videotapes, such as news clips, or "live" sound recordings of people, places, and things? Or, perhaps, does it appear to be close to "real life" in its content in another way, by containing, for example, portrayals of current or historical human dilemmas or even situations common to everyday life?

The '88 Vote and *In The Holy Land* both offer the compelling realism of news footage, despite the fact that one key component of news realism—the "this is happening now, as you watch" sense of simultaneity—is clearly missing. Nor were the familiar faces of network news anchormen important to our reviewers. Instead, the programs' compelling quality lay in their capacity to bring aspects of the world that are difficult to represent in the classroom (fractious political campaigns and arguments over the meaning of events in the Middle East) into the grasp of teachers and students.

Two black girls using *The '88 Vote* for the first time, for example, went immediately to footage of the Reverend Jesse Jackson, a figure of clear personal significance, and began a discussion that proceeded from his similarities to their fathers to the components of his oratorial style, and then to speculations about how Michael Dukakis' lack of such style may have hurt his chances. For the teachers, the ability to treat video "documents" (for example, video clips of campaign commercials, file footage of important events in Mid-East history) as original source materials for study made particular sense, since the media played an important role in shaping both of the topics portrayed, and the power of the media is a "real-world" fact that they seldom have an opportunity to confront directly.

d. **Point of View.** Is the content biased in some way? Does it present a particular perspective? Or, does it attempt to include information from multiple perspectives and disciplines? Does it include multiple and contrasting ways of looking at and thinking about things? Is it emotional in some way, or strictly factual?

Life Story is based on the story of the discovery of DNA's structure and portrays the research pursuits of several scientists. By exploring information about the progress of each of these scientists, the user of *Life Story* begins to see this collective research effort from a variety of perspectives. The program provides a framework of questions, historical facts, and competing interpretations of events which, taken together, enable the user to evaluate not only the issues of collegial collaboration, competition and sexism in the scientific

community that are the subject of the television drama, but also how the biases of television itself are reflected in the ways these issues are presented.

In a more literal way, a design example such as *The Visual Almanac* presents information from different points of view in activities like Playground Physics. For example, in the "Merry-Go-Round" activity, images of a merry-go-round in motion are displayed, juxtaposed with graphical representations and numerical charts of changes in various data associated with the motion of the merry-go-round, such as velocity and time. In this way, users can begin to see abstract principles via simulations with concrete examples. Elsewhere, split-screen imagery is used to show users up to four different views of the same complex physical motion.

e. **Connection to Curricula.** Is the content of the database explicitly tied to any particular curriculum or grade level? Or is it perhaps multidisciplinary and appropriate for a variety of age and skill levels, with more flexible connections to a variety of curricula? Can it be used in nontraditional learning environments, like homes and museums, as well as classrooms?

Among those programs dealing with a relatively focused content area, *The '88 Vote* and *In The Holy Land* implied very strong curricular connections to the teachers and students, but actually supplied few explicit opportunities or models for such connections to be pursued. Questions and activities were suggested in accompanying print materials, but were not integrated into the materials themselves. In these and most other programs, the grade levels for which the materials might be appropriate are not specified. For the most part, however, the reading levels implied by the materials indicate that the intended age groups are junior high to high school students. Exceptions occur in both *NOVA: Animal Pathfinders* and *The Visual Almanac*, where highly visual game-like activities are clearly appropriate for much younger students. These were also the programs most likely to incorporate elements of games and tightly focused activities that would be appropriate to nontraditional learning environments like museums and homes.

The multidisciplinary, multi-perspective *Life Story* is a good example of a program that offers explicit on-line links to curriculum ideas and activities. In a section reviewing the discovery of DNA through a dramatized TV narrative, users may call up questions that focus their attention on details of of the drama's setting, character, and tone, as well as the historical relationships portrayed. In a section on the structure of DNA, students are given instructions for building their own model of DNA, including dotted-line cutouts that can be printed out of the computer. In addition, the program provides teacher-created lesson plans that convey not just a recipe for using the materials, but also concrete stories of how individual teachers came to grasp and use them.

In terms of the **structure of the database**, one might ask:

a. **Nature of the Raw Materials.** What is the basis for the particular compilation of information in the database? How did it originate? For example, is it based on an existing film archive or, perhaps, on a particular documentary film, drama, or book? Is it, perhaps, a customized collection of information acquired from a variety of sources, or a collection of new materials created explicitly for the database? Was it compiled with a particular philosophical or pedagogical ideal in mind? A particular learning goal? Some combination of these?

For example, the design examples from ABC Interactive, such as *The '88 Vote* and *In the Holy Land*, are based largely on the extensive archives of ABC News. The databases involved were created primarily from existing news footage. As such, these design examples provide an ideal window for considering the role of media in informing us of world events, and can be used by teachers to illuminate various crucial issues related to media literacy, in addition to their other content goals.

Life Story is based largely on a televised drama, *Life Story: The Race for the Double Helix*, produced by BBC Television in association

with the Arts and Entertainment Network. *Interactive NOVA: Animal Pathfinders* is based largely on a televised documentary produced by Peace River Films for WGBH-TV Boston's NOVA series. Thus, these design examples involved the creation of multimedia databases from preexisting linear video programs.

The National Gallery of Art and *Van Gogh Revisited* are based largely on collections of works of art, one a museum collection and one a compilation of works by one artist gathered from a number of museums around the world. Both include original video created specifically as contextual backgrounds for the various collections and works of art.

The Visual Almanac is based on both a customized collection of information from a variety of sources and a collection of new materials created specifically for the program. *Ramos* , created by Piagetian researchers in Geneva, Switzerland, is an interactive story based on still photographs of life in a Salvadoran city but, just as important, on a particular pedagogical and philosophical outlook that emphasizes moral development, ethics, and problem solving.

b. **Browsing vs Direct Searching and Sorting.** Is the structure of the database designed so that novices, as well as other users, can browse in an exploratory way and discover information in the course of their browsing? Or is it structured so that, with some knowledge in hand, users can enter key words or phrases to search directly and quickly through the database to specific pieces of information? Or some combination of both?

Most of the design examples reviewed offer combinations of browsing and direct searching capabilities. With those that use videodiscs, for example, users can browse visually through the videodisc images via the remote controller in scan, fast forward, play forward, play reverse, or step modes. With *Interactive NOVA: Animal Pathfinders* users can, for example, browse through hierarchies of information categories displayed graphically on the screen. With *The Visual Almanac*, users can browse hierarchically from the collections menu to chapter headings within each menu to individual "pages" within chapters, as well as search directly by available key words and image keys or by entering key words directly via the global "search" or "find" feature.

c. **Use of Contextual Metaphors and Organizers.** Is a global metaphor used to help organize the information and contextualize the experience for users? Is it based on familiar environments or activities? Is the database structured around a particular space or place or, perhaps, around the narrative elements of theme, place, character, conflict, and/or plot sequence associated with a particular story? Or does its structure draw from creating the illusion of the functional conventions associated with using and navigating through a familiar environment, such as a library, cafeteria, or city street? Or using some familiar object, such as a camera, telephone, or ruler? Or some combination of these?

For example, with *Ramos*, a global metaphor for the entire database of information is used to help structure the interactive experience for users. This includes the spatial, concrete metaphor of an urban neighborhood and various narrative elements that might be related to it, including the people who live in the neighborhood and the activities and dilemmas which might characterize life there.

The Visual Almanac incorporates several local metaphors that are specific to particular collections of information or activities. For example, in thePlanetary Highway activity, the metaphor of a highway is used to help instill in users an intuitive sense of the scale of the universe. Objects of various sizes were selected to represent each planet in our solar system. These objects were placed at various distances along a highway down which the user can "travel" at different speeds to begin to experience the relative size of the solar system and to begin to see the relationship between time and distance.

d. **Structured Activities.** Does the database include learning activities of some kind that are designed to illuminate the information contained in it and provide springboards for association, reflection, and insight? For example, are provocative study ques-

tions provided? puzzles to solve? role-playing activities? exploratory "treasure hunt" games? experiments that involve the manipulation of variables (images, sounds, words, or data)? Is feedback of progress or "success" provided to users who pursue these activities?

In *Ramos*, the entire program takes the form of a loosely structured activity: Users play the role of a lawyer who must build a defense for a Salvadoran street boy accused of selling drugs. For our student reviewers, this role-playing structure lent coherence and continuity to the wide range of intellectual tasks that the program presents. The *Visual Almanac* includes a variety of more local activities that help to focus reviewers' encounters with the material, to convey particularly abstract concepts, and to demonstrate ways that teachers and students can structure the materials for their own pedagogic and creative purposes.

But perhaps the most impressive and, with our reviewers, compelling and fun use of structured activities was in *Interactive NOVA: Animal Pathfinders*, a program that presents three different activities, each of which models a different aspect of scientific inquiry and demands a different level of intellectual engagement. "Turtle Mystery" is an adventure game in which the user becomes a reporter investigating reasons for the gradual disappearance of sea turtles from the Florida coast. It calls for thorough observation and attention to detail, and was easily accessible to our youngest reviewers. "Bee Dances," an exercise in learning to "read" the information conveyed by the movements of honey bees in their hives, is somewhat more challenging, encouraging trial-and-error experimentation and offering as tools several abstract drawings of the relationships involved. The most sophisticated activity is "Monarch Migration," in which users proceed step by step alongside real scientists in reenacting an actual field investigation into the Monarch butterfly's migration patterns. With its careful modelling of the different phases of the experimental method, this activity provided over an hour of challenging work by high school and adult reviewers, and led to interesting discussions among teachers about pedagogy in science.

In terms of **the user interface for accessing information** in the database, one might ask:

a. **Contextualizing Overview.** Does the interface include an introductory overview of some sort that describes the nature of the multimedia application, what information it contains, and how to use it?

For example, *Interactive NOVA: Animal Pathfinders* has a linear video overview that introduces the content of the database as well as the structure—overviews, database, activities, and resources. Additional video overviews are available that describe how to use the interactive program and introduce various themes and concepts pertinent to the database.

It appeared that introductory overviews were more important for adult reviewers than for kids, who tended to skip all top-down overviews and preferred to develop a sense of the program's structure by jumping in and "messing around."

b. **Locational Information.** Does the interface always make information available to users about where they are in the database, so that they never feel "lost"? Locational information might be in the form of maps, indexes, backtracking information, labels, highlights, you-are-here arrows, etc.

The presence or absence of these cues, and their usefulness, often influenced the duration, depth, and quality of reviewers' interactions with a particular program. Where "maps" of the database content and the user's location in it were not easily available, reviewers sometimes missed important parts of the program or, momentarily unsure of how to reorient themselves, skipped out of the program altogether. Especially helpful in this regard were schematic maps that conveyed the scope of the program's content, as well as its structure. In *Interactive NOVA: Animal Pathfinders*, the user's location in the database is displayed in a tree-diagram that also reinforces a key part of the content—the classification of plants and animals. In addition, the program's designers correctly anticipated that users would find it

convenient to use the diagram as a navigational tool, and so allowed movement from one part of the program to another via this "map."

c. **Visual or Spatial Access.** Does the interface provide familiar images and/or spaces as navigational cues and menus to information? Visual or spatial access might be provided in the form of maps, timelines, pictures, charts, pictographic icons, simulated three-dimensional spaces, etc., in addition to, or in place of, menus based only on words or lists of words.

All of the programs reviewed rely upon visual access of information; some, however, choose creative means of representation that are not only intuitive, but subtly reinforce the content being presented. For example, in a section of *The Visual Almanac* titled "A Day in the Life...," a world map is used to call up photos of cultures from around the globe. Field photographs become menus for the study of life outdoors in the "Monarch Migration" section of *Interactive NOVA: Animal Pathfinders*. And in both *Ramos* and NOVA's "Turtle Mystery" game, simulated three-dimensional spaces are used as effective means of engaging students in an imaginative role-playing exercise.

d. **Multiple Options.** Does the interface provide multiple options to users for navigating through, accessing, and displaying the information in the database? Are there multiple levels of information content? multiple media formats used? multiple levels of experience—concrete, experiential, visual, and abstract? multiple navigational decision points and pathways?

All of the design examples reviewed include multiple navigational options, due partly to the discovery orientation they all share. For example, the use of pictographic icons as buttons, and images as menus are common to most of the design examples reviewed and allow for multiple pathways, individualized by the interests of each user, through each database. With the exception of *Ramos* and *Exploring the Moon*, which do not include videodiscs, all of the design examples reviewed use multiple media formats—motion video, slides, text, sounds, and graphics.

In terms of multiple levels of experience, *Interactive NOVA: Animal Pathfinders* provides some interesting examples. Its three activities, for example, represent different levels of scientific investigation, from the "Turtle Mystery" (which involves exploration and data collection), to the "Bee Dance" activity (which involves observation and pattern matching), to the "Monarch Migration" activity (which involves data collection and manipulation, as well as pattern recognition). These activities also represent a progression from concrete, experiential (Turtle Mystery) to visual (Bee Dances) to abstract (Monarch Migration).

e. **System Responsiveness and Consistency.** Does the interface include conventions that provide users with quick, explicit responses to their inputs that operate in a consistent way? These might include auditory, visual, and/or text-based responses. Does it allow for any action that has been done to be undone? Is there a way to get help?

Our reviewers rarely used help. They preferred to try an option and see what it would do rather than read about it first. This put a premium on interface consistency and responsiveness. Nearly all the programs achieved this, but more ambitious programs like *The Visual Almanac* sometimes sacrificed consistency for breadth of choice in options. The importance of responsiveness was underlined when a program became too large for the computer it was running on, and so operated at less than its normal speed. The resulting sluggishness of response frustrated users.

In terms of the various **interactive tools for manipulating the information** in the multimedia database, one might ask:

a. **Personalizing.** Are tools provided that allow users to manipulate the information in the database in a way that is meaningful to them? For example, can users "bookmark" information that is interesting to them? Can they store it somewhere and label it for later retrieval? Can they take notes that are preserved on the system? Can they print out information or images?

Local note-taking features, such as those provided in *The Visual Almanac* and global notepads like those in the two ABC programs, are being incorporated into more and more databases. Students were not likely to use either of these features when they were simply browsing the database, but teachers recognized the more local notepads as useful ways for them to pose questions to students and have students record and compare their different responses. The size of some of the notepads limited the scope of these interactions, however. Most programs also offer options for printing individual screens, but few do so as conveniently as *The Visual Almanac* or *In the Holy Land*. The latter program offers the option of exporting text passages directly into users' personal files, for use in reports, etc.

b. **Searching, Sorting and Browsing Tools**. Are different modes of browsing the database provided? Do these allow for specific key-word searches, as well as more relational modes of sorting?

The program that offered the most diverse and instructive modes of database browsing was *The Visual Almanac*. From every database object users can search via general or specific key words, or select a "wild-card" option that searches randomly within the current stack. In between these constrained and unconstrained modes, however, are two relational modes of browsing. Every image-oriented object in the database is accompanied by two lists of words—one of the subjects the picture refers to, the other of the pictorial elements it contains. Selecting any word initiates a search to its next instance in the database. Users can thus browse along one conceptual or pictorial dimension, or switch at any time and browse another path. Teachers felt these options would be useful tools for developing students' abilities to categorize and to think relationally.

c. **Linking and Tracing**. Are tools provided that allow users to connect previously disconnected pieces of information together, to annotate these links, and trace back through the links?

Every program that includes "authoring" tools for users to gather and annotate images and text offers opportunities for students to link together disparate images and information. *The Visual Almanac* is notable in that it offers menus of all the sounds in the database as well as the images, thus making linking of sounds possible. The most flexible environment for linking information, however, was *Exploring the Moon*, a hypertext application that allows users to create and follow any number of links within and between text documents and scanned images. For children following premade links, however, it appeared that the amount and form of the information available to explain the links was often not sufficient to give them an understanding of how one passage or picture related to another.

d. **Editing and Authoring**. Are tools provided that allow users to edit the video, audio, and text information in the database; reconstruct it; create new juxtapositions; enter new text; and thereby produce multimedia "reports" or presentations (based largely on the rearrangement of information in the database)?

For example, *The '88 Vote* and *In the Holy Land*, both by ABC Interactive, include "documentary maker" tools with which users can begin to compile their own sequences of news clips by "editing" together clips that exist on the videodiscs. Likewise, *Interactive NOVA: Animal Pathfinders* has a "video editor" that allows users to edit together and customize the length and frame rate of any video clip on the videodisc. *The Visual Almanac* has "composition tools" and *Interactive NOVA: Animal Pathfinders* has a "report-maker" that allows users to produce multimedia documents composed of video and audio (from the videodisc) as well as text. Text can be imported from the database or entered directly via the keyboard.

e. **Producing, Composing, Programming**. Are tools provided that allow users to input new information (scanned images, digitized sound, graphics, text) to create their own, original multimedia "productions," such as motion video sequences with accompanying text and audio narration?

None of the design examples reviewed had these functions available (with the exception of text entry). Extra hardware (such as cameras, microphones, video tapedecks, im-

age scanners and capture boards, and audio digitizers), as well as software tools, are necessary to make this kind of production process available.

SUMMARY

This paper has presented an introductory framework for reflecting on the issues involved in the design of discovery-based, interactive multimedia programs. It is based on reviews of ten multimedia design examples by small groups of designer/researchers, teachers, and children. Through a synthesis of these reviews, three basic design components were identified as central to all of the multimedia design examples reviewed: (1) a database of information, its content and structure; (2) a user interface for accessing the information; and (3) interactive tools for manipulating the information. Design questions and examples related to each of these components have been presented with the hope that educators will begin to reflect more critically on design issues relevant to discovery-based multimedia programs and thereby begin to understand and choose more selectively multimedia materials appropriate to their particular learning and teaching needs.

Notes

1. The work summarized here represents the second phase of an ongoing program of research around new multimedia resources for education. The aim of this research is not so much to guide educators in adopting this or that particular program, but to alert them to a range of variables that together will help to determine the success or failure of any effort to integrate these demanding yet promising materials into environments for children's learning. The first step in our research was an investigation of multimedia learning in the largest sense. In a paper titled "Designing for Discovery: Interactive Learning Environments at Bank Street," recent developments in multimedia computing were viewed in light of a long tradition of environmental design for education, in particular, a Bank Street approach stressing interactions within a rich learning environment, and the student's central role as an agent in discovering connections between ideas.

The present paper represents the second step in our research: a consideration of new multimedia resources themselves, what they might offer the teacher and student that is unique and powerful, and what design features might either enhance or impede their usefulness for teaching and learning. The third step in our research, based on preliminary field studies of multimedia computing in different schools, is an examination of many of the things that are required to make classroom integration of multimedia materials work, from a flexible classroom setting to teachers with enough time to preview, introduce, and customize the materials. Throughout this work, our goal is to suggest ways of thinking critically about these new materials that will put educators in a better position to integrate them successfully into the teaching and learning enterprise.

2. Nearly all of our design examples were Macintosh, videodisc, and HyperCard-based applications whose development was supported in part by Apple Computer, Inc. In part, this was because Apple was generous with donations of equipment and software to our multimedia lab. Such donations go hand in hand with their support of the software developers who are creating innovative programs: Both are efforts to stimulate an educational market for Apple-based multimedia computing. Yet, because of these efforts, Apple is widely regarded as the leader in applying multimedia to education. HyperCard has gained a wide reputation as a powerful yet flexible browsing environment and authoring program appropriate for teachers and children. In their integration of the different media, many HyperCard-based multimedia programs represent the state of the art in multimedia computing. Finally, the open-endedness of many of the Apple design examples makes them appear conducive to the more active, learner-directed modes of inquiry that we at Bank Street believe are important. For example, the Apple design examples always include built-in opportunities for student authorship and teacher customization.

3. It should be emphasized that the effectiveness of new educational materials cannot be judged on the basis of a few hours' use by a handful of people in a laboratory setting. If the multimedia materials were designed for classroom use, lengthy field testing in very different kinds of schools and classrooms by very different kinds of students and teachers is the only adequate measure of a new program's potential. This is especially true of interactive programs whose size and nonlinear nature may require far more time to explore fully than other educational programs designed to be used in a more linear, structured way. Again, our aim was not to judge or compare these particular programs, but to gather from them a sense for which creative design conventions are being successfully used to attract and engage students and teachers, and which problems have yet to be addressed.

Related Readings

Ambron, S., & Hooper, K. (Eds.). (1990). *Learning with interactive multimedia: Developing and using multimedia tools in education*. Redmond, WA: Microsoft Press.

Ambron, S., & Hooper, K. (Eds.). (1988). *Interactive multimedia*. Redmond, WA: Microsoft Press.

Bolt, R. A. (1984). *The human interface: Where people and computers meet*. Belmont, CA: Lifetime Learning Publications.

Nickerson, R. S. (1986). Using computers: *Human factors in information systems*. Cambridge, MA: The MIT Press.

Norman, D. A., & Draper, S. W. (1986). *User center system design: New perspectives on human-computer interaction*. Hillsdale, NJ: Erlbaum.

Tally, W., & Char, C. (1987). *Children's use of the unique features of interactive videodiscs*. New York: Bank Street College of Education, Center for Children and Technology.

Wilson, K. S. et. al. (1987). *A design scrapbook of discovery experiences in multi-dimensional worlds*. New York: Bank Street College Project for Apple Computer, Inc.

Wilson, K. S. (1988). The Palenque optical disc prototype: The design of a multimedia discovery-based experience for children. *Children's Environments Quarterly*, 5(4), 7–13.

Wilson, K. S., & Tally, W. (1989). *Designing for discovery: Interactive multimedia learning environments at Bank Street College*. New York: Bank Street College of Education, Center for Technology in Education.